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COMPUTERIZED GRAPHICAL REPRESENTATION OF TYPES OF DESTRUCTION OF HARDENED GLASS

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A general method, an algorithm, and results of computer modeling of destruction of hardened sheet glass under conditions approximating testing of real products are described. Recommendations for further improvement of the program are given.

Computational methods [1, 2] for predicting the nature of destruction of hardened sheet glass make it possible to determine the total number of fragments N per prescribed surface area of the article (5 × 5 cm), assuming uniform distribution of them on the surface and identical shape (parallelepiped) and size of each fragment. Testing of samples according to GOST 5727–88 yields a certain spread in these parameters.

The present paper attempts to give a computerized graphical representation of destruction of sheet glass under conditions approximating real conditions for product testing.

The development is based on analytical dependences obtained earlier [2].

In particular, the average length of a side of the base of a fragment is equal to [2]

$$\bar{Z}_{\text{av}} = \frac{4}{\pi}\left(\frac{6E\gamma}{\sigma_{\text{av}}^2(1-2\nu)} + \frac{\delta}{\sqrt{3}}\right),$$

where E is the modulus of elongation; γ is the specific surface energy; σ_{av} is the central tensile stress; ν is the Poisson coefficient; δ is the glass thickness.

The average number of fragments for the length B of a side of a square plate will be

$$N = B^2/\bar{Z}_{\text{av}}^2 .$$

It is assumed that the crack grid is formed by N_r rows, each containing N_r fragments. The destruction representation scale is determined:

$$\text{mas} = 400/B,$$

where 400 is the sheet side size in pixels (a pixel is a conventional measurement unit for a computer display; one conventional unit ranges from 0.25 to 0.28 mm).

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The average length of a base side of a fragment represented on the computer display is

$$Z_{\text{av}} = (B/N_r)\ \text{mas}.$$

Experimental data show that fragments become larger as they recede from the center of destruction (by the standard, this is the geometric center of the article). We assume that within the confidence interval ± 20%, the variation in Z (Z is the length of a base side of a fragment represented on the computer display) as it recedes from the center of destruction will be

$$0.8Z_{\text{av}} \le Z \le 1.2Z_{\text{av}} .$$

These initial data were used as the basis for an original computer program "SETGRAPH" providing a graphical representation of destruction of hardened glass. The general structure of the program is as follows.

One of the main purposes of the program is to position the center of each fragment, taking into account the preset variation in the length of a fragment side. First, the centers of fragments of the first row are positioned, the ordinal number of the fragment k ranging from 1 to N_r. The distance between fragment centers is found from the formula

$$\Delta X0\,[m, k] = \left|\frac{N_r}{2} - k\right| B_t + 0.8Z_{\text{av}},$$

where m is the ordinal number of the row in which the fragment is positioned on the display; k is the ordinal number of the fragment in the row; $0.8Z_{\text{av}}$ is the arbitrarily adopted minimum length of a fragment side; B_t is the absolute value of the difference in the length of a side of the preceding and following fragments in the row with the number m,

$$B_t = |Z\,[m, k-1] - Z\,[m, k]| = \frac{0.4Z_{\text{av}}}{N_r/2},$$

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where $0.4Z_{av}$ is the difference between the maximum and minimum length of a fragment side.

As a result, the coordinate along the X axis for the center of fragment k in row m will be

$$X0\,[m, k] = X0\,[m, k-1] + \Delta X0\,[m, k].$$

The value of the coordinate along the Y axis for the centers of the fragments in this row is constant.

Next we construct the angles between the base sides of each fragment shown on the display (Fig. 1). A fragment is arbitrarily split into four sections, the coordinates of each vertex being determined:

$$X\,(m, k, i) \text{ and } Y\,(m, k, i),$$

where i is the number of the fragment angle, ranging from 1 to 4.

Let us assume that all vertices of the fragment base are equally far from its coordinate origin (Fig. 1), i.e., are positioned on a circumferences with the radius $R\,[m, k]$. The value of the radius is different for each fragment and is found as follows:

$$R\,[m, k] = Z\,[m, k]\,\frac{\sqrt{2}}{2},$$

where

$$Z\,[m, k] = \left|\frac{N_r}{2} - \left[\frac{k+m}{2}\right]\right| B_t + 0.8Z_{av}.$$

We assume that the shortest distance from a base vertex to the Y axis is

$$L_X[m, k, i] = \text{random}\,(0.6R) + 0.335R,$$

where $0.335R$ is the arbitrarily adopted minimum possible distance from the vertex to the Y axis; $0.6R$ is the difference between the arbitrarily adopted maximum ($0.935R$) and minimum distances from the vertex to the Y axis.

The symbol "random($0.6R$)" in the above relationship is a function that generates a random number in the interval ($0.6R$).

The shortest distance from a base vertex to the X axis is

$$L_Y[m, k, i] = \sqrt{R^2[m, k] - L_X^2[m, k, i]}.$$

The base vertices on the display are connected by continuous lines, which represent the crack grid of the destroyed hardened glass.

The initial data (processed by the SETGRAPH program) make it possible to obtain a crack grid for hardened sheet glass up to 0.9 m^2 in size with the number of fragments ranging from 0 to 200. An example of the graphical representation of destruction of hardened glass is shown in Fig. 2.

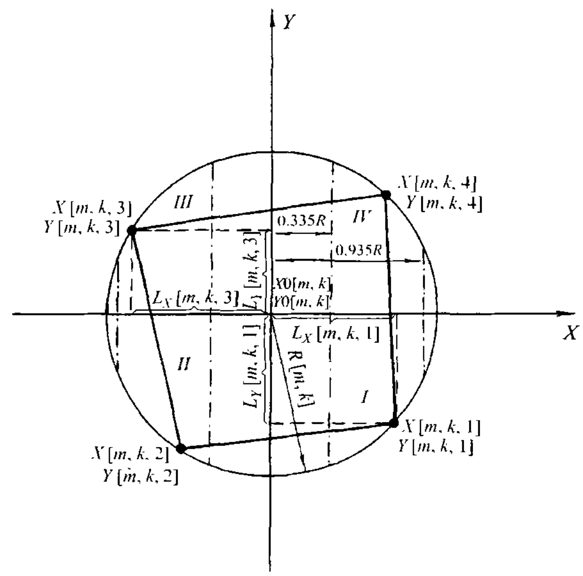

Fig. 1. Scheme of the glass fragment structure: I – IV) quarters into which the fragment is split.

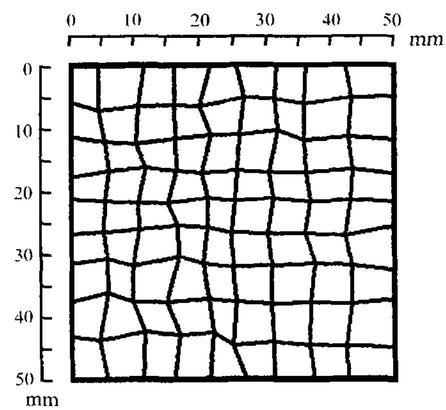

Fig. 2. Example of the graphical representation of destruction of hardened glass ($N = 81$, size of a sample side 50 mm).

A special feature of the developed program is the possibility of introducing any distribution law for the size of a fragment side, for instance, the Gauss law, and of changinng the shape of the simulated fragments.

REFERENCES

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